NISTIR 6890

Fire Resistance Determination and Performance Prediction Research Needs Workshop: Proceedings

William Grosshandler
Editor

NIST
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L. Performance-Based Analytical Prediction of Fireproofing Requirements in Complex Buildings, Robert H. Iding, Wiss, Janney, Elstner Associates, San Francisco
(See file App III L.pdf)

Performance-Based Analytical Prediction of Fireproofing Requirements in Complex Buildings

By Robert H. Iding

Wiss, Janney, Elstner Associates, Inc.

Research Needs for Fire Resistance Determination and Performance Prediction

National Institute of Standards and Technology

Gaithersburg, MD

February 19 and 20, 2002

WJE

Analytic Approach to Fire Safety Design

- Possible fire exposures based on site-specific conditions (fuel load, ventilation, etc.).
- Temperature history during fire calculated by heat conduction computer programs.
- Based on calculated temperatures, fire endurance determined using structural analysis computer programs.

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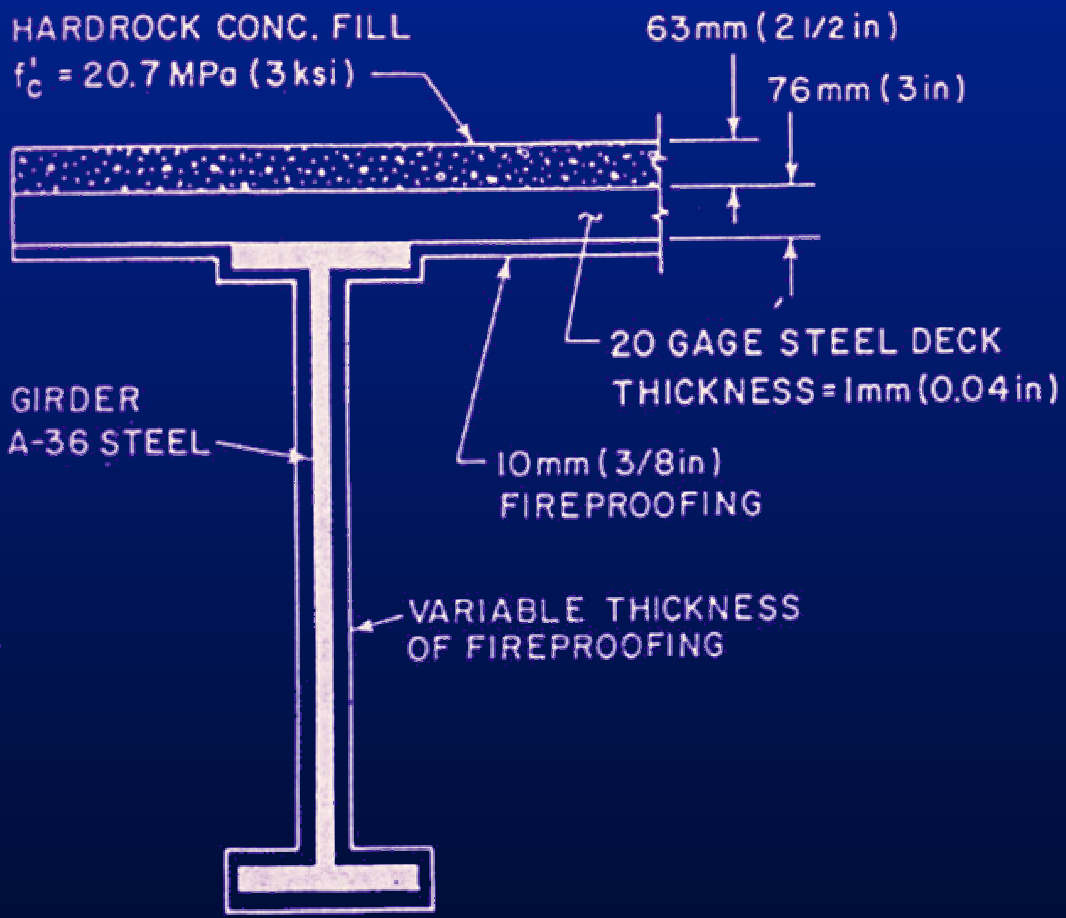
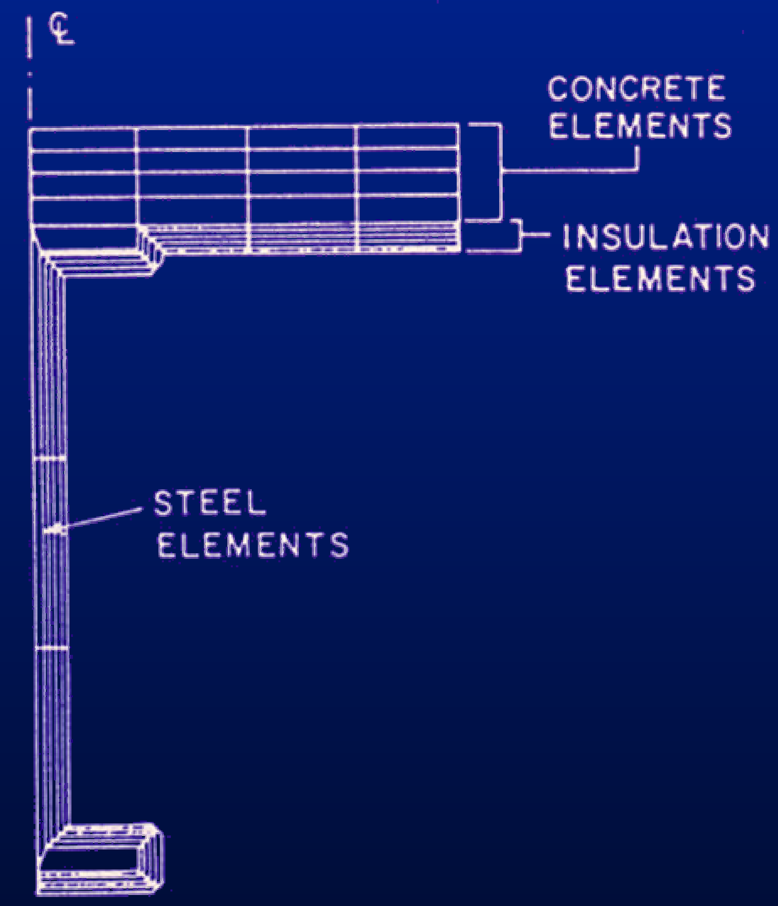

HARDROCK CONC. FILL
f'_c = 20.7 MPa (3 ksi)
63mm (2 1/2 in)
76mm (3 in)
20 GAGE STEEL DECK
THICKNESS = 1mm (0.04 in)
GIRDER
A-36 STEEL
10mm (3/8in)
FIREPROOFING
VARIABLE THICKNESS
OF FIREPROOFING


℄
CONCRETE
ELEMENTS
INSULATION
ELEMENTS
STEEL
ELEMENTS

Heat Conduction Equation

$$\rho C \frac{\partial T}{\partial t} + K \nabla^2 T = Q$$

where	ρ	=	density of steel
	C	=	specific heat capacity of steel
	T	=	temperature distribution in column
	t	=	time
	K	=	heat conductivity of steel
	Q	=	heat input into column
	$\nabla^2(\,)$	=	$\frac{\partial^2(\,)}{\partial x^2} + \frac{\partial^2(\,)}{\partial y^2} + \frac{\partial^2(\,)}{\partial z^2}$

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Fire Boundary Conditions

$$Q = A\,[\,C\,(T_f - T_s)^N + V * \sigma\,(a\varepsilon_f\theta^4_f - \varepsilon_s\theta^4_s)]$$

where	A	=	surface exposed to fire
	C	=	convection coefficient
	N	=	convection power factor
	V	=	radiation view factor
	σ	=	Stefan-Boltzmann constant
	a	=	absorption of surface
	ε_f	=	emissivity of the flame associated with fire
	θ_f	=	absolute temperature of fire (°R)
	ε_s	=	surface emissivity
	θ_s	=	absolute temperature of surface (°R)
	T_f	=	fire exposure temperature (°R)
	T_s	=	steel temperature (°R)

Matrix Heat Conduction Equations

$$[C]\{\dot{T}\} + [K]\{T\} = \{Q\}$$

[C] = Capacity matrix (temperature-dependent)

[K] = Conductivity matrix (temperature-dependent)

{Q} = External heat flow vector (depends on exothermic reactions and fire boundary conditions)

{T} = Temperature vector (time-dependent)

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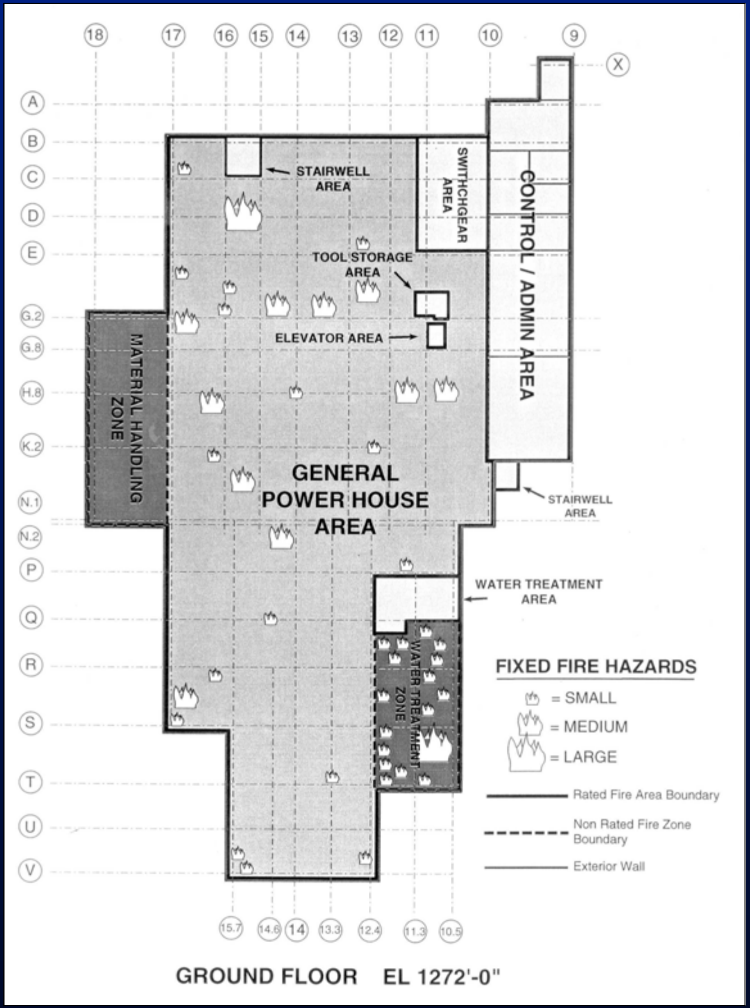
Fixed Fire Hazards on Ground Floor of Healy Power Plant



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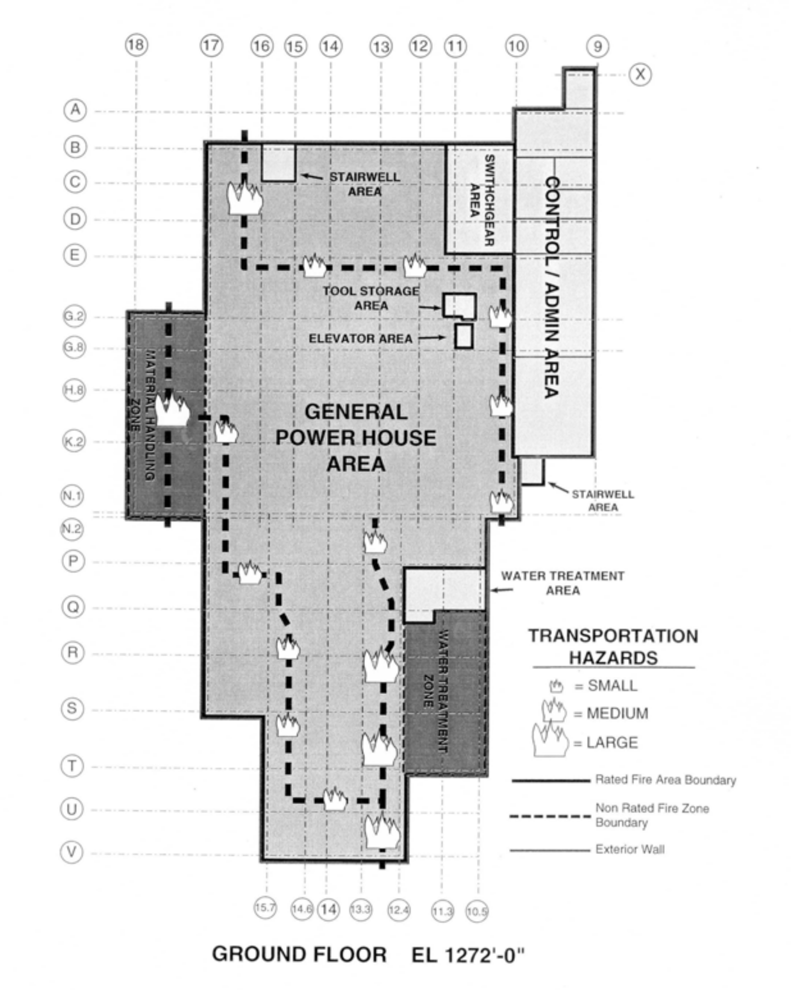
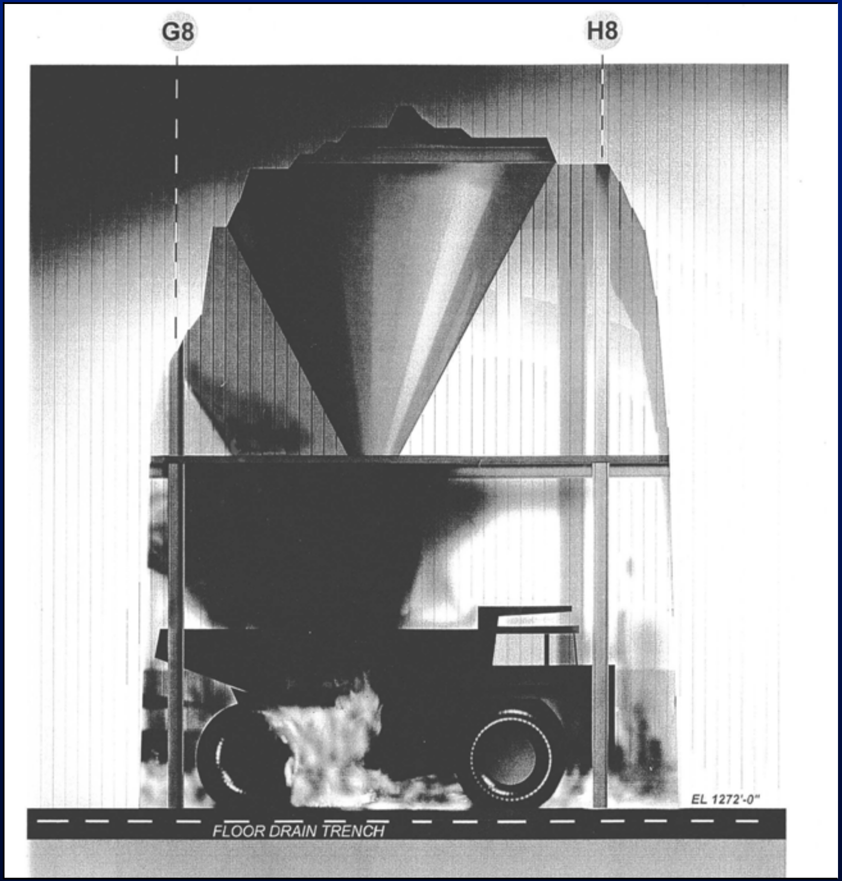
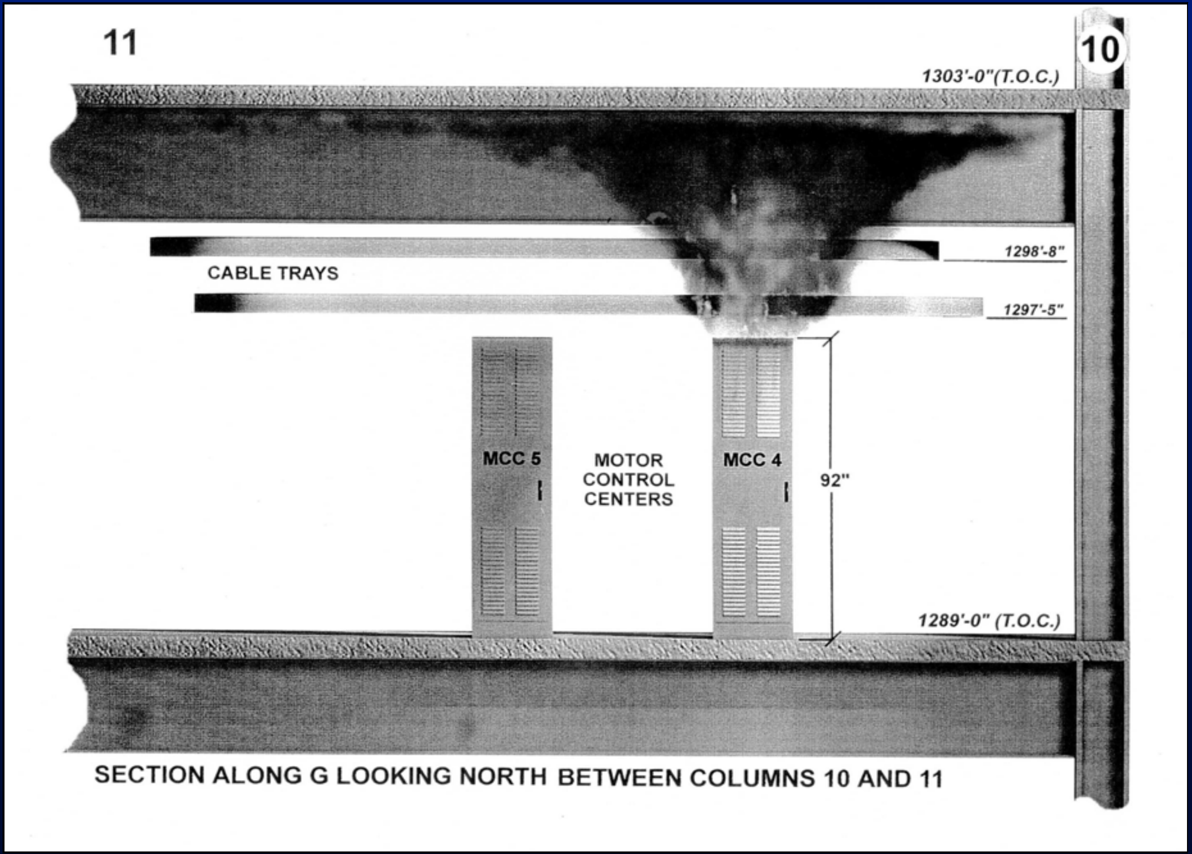
Transportation Fire Hazards on Ground Floor of Healy Power Plant



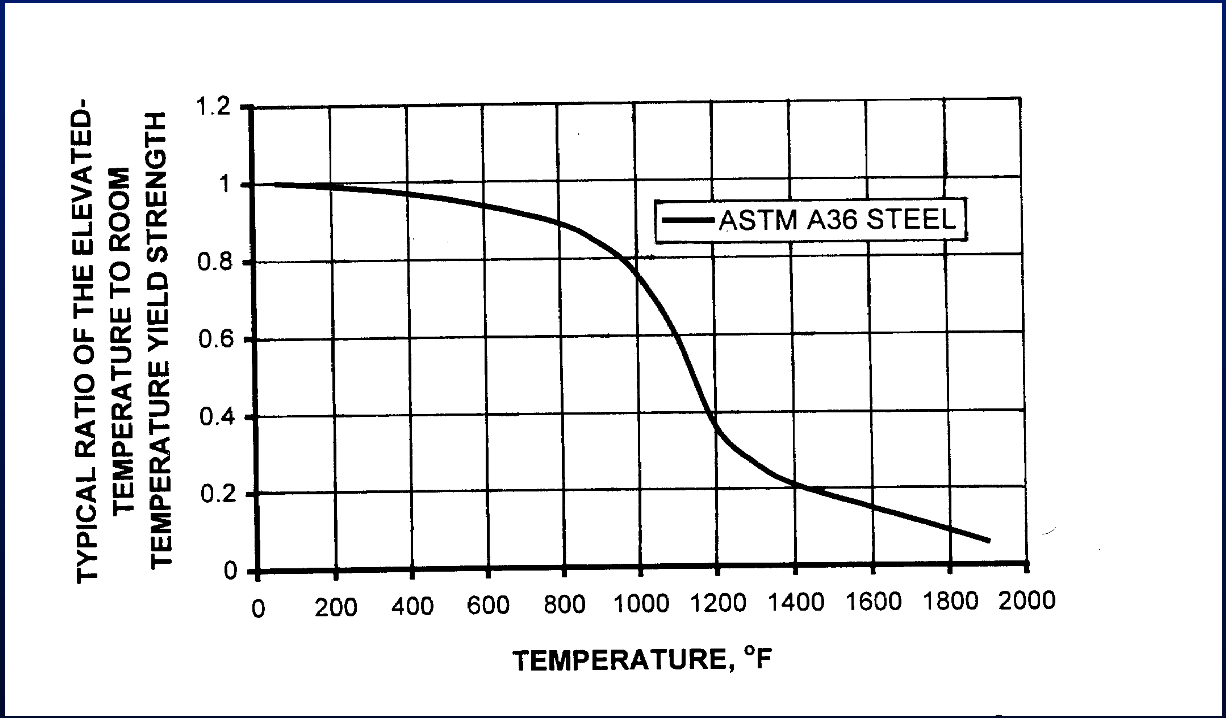
Large Truck Fire Scenario



Motor Control Center Fire Scenario



Effect of Temperature on the Ratio Between Elevated-Temperature and Room-Temperature Yield Strength of Steel



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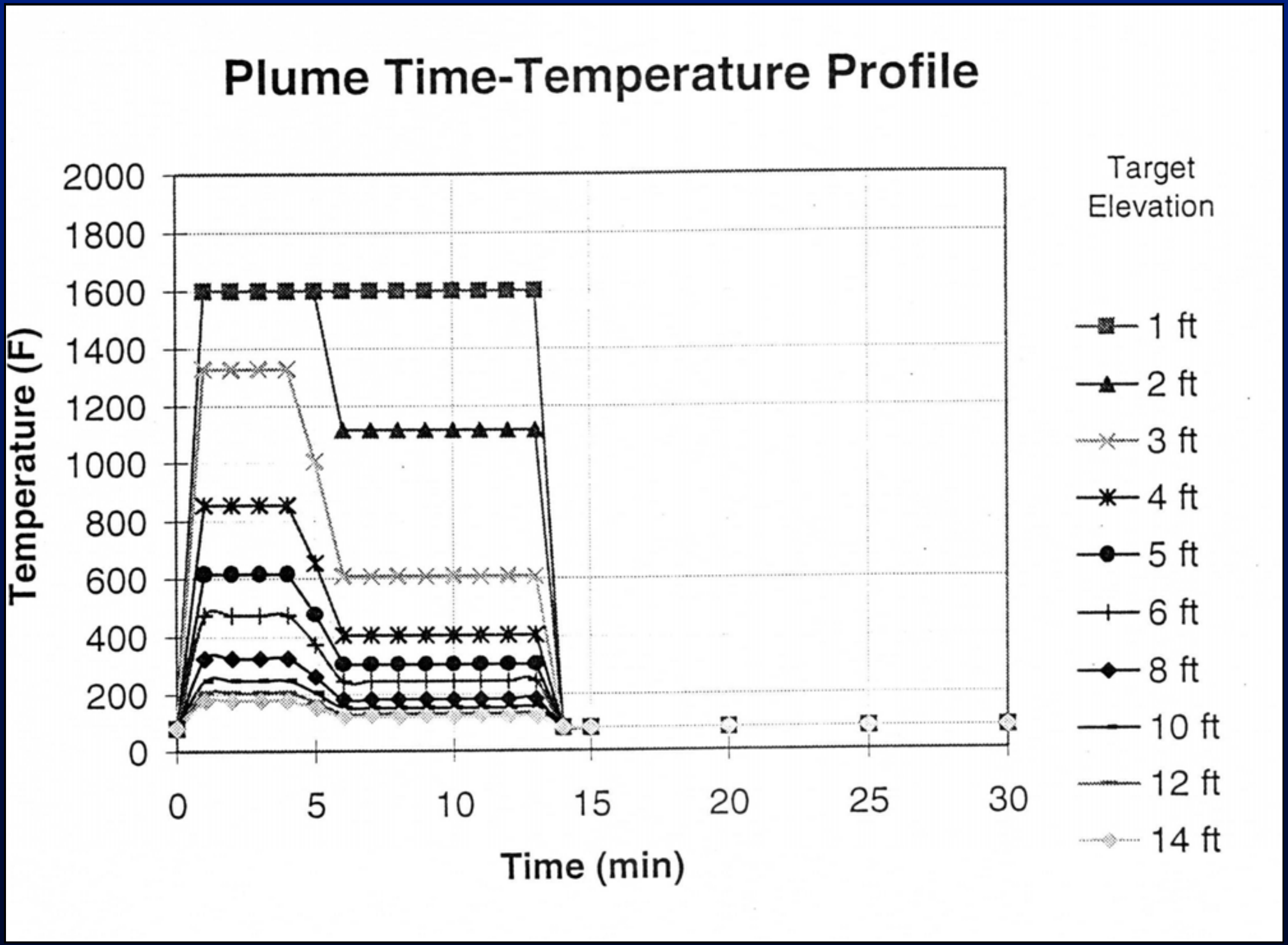
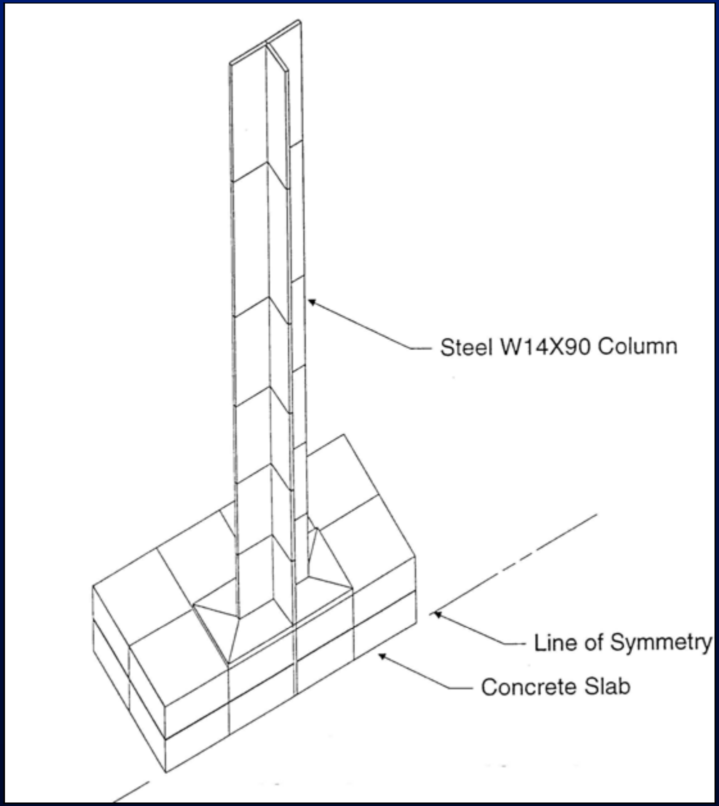
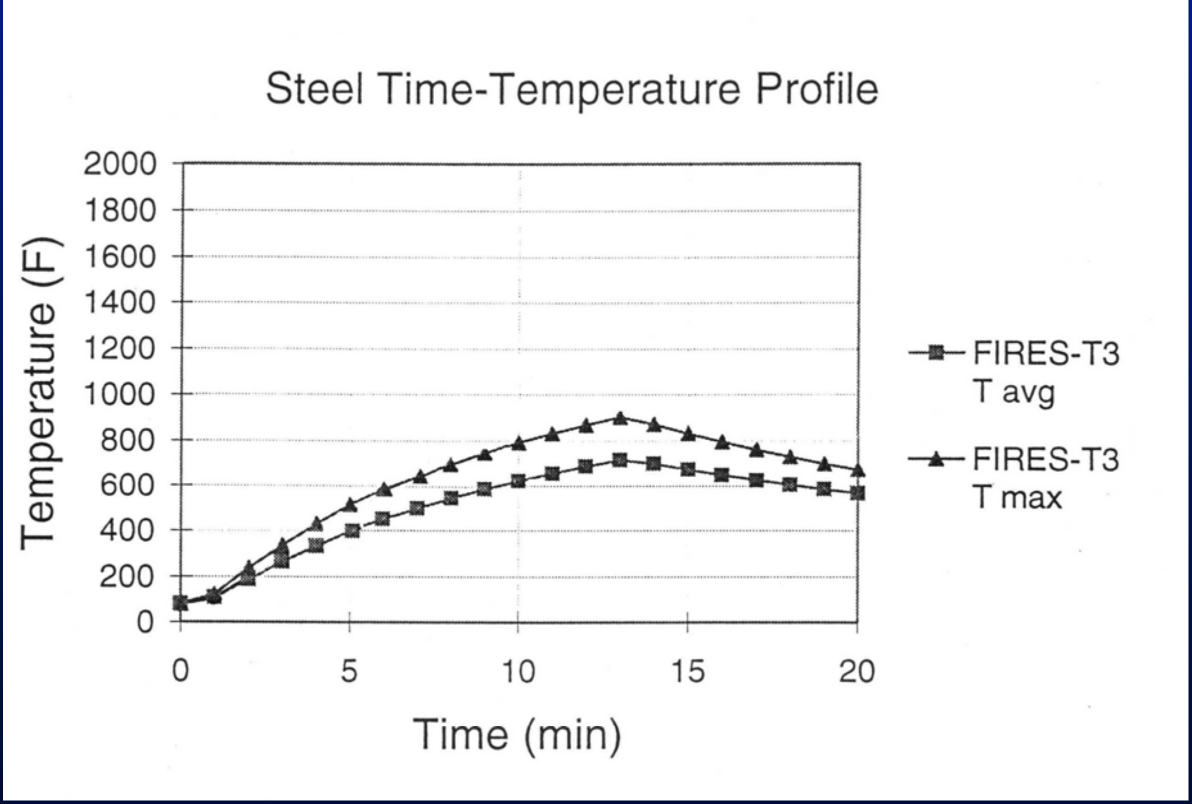
Column Exposure Temperatures from Maintenance Refuse Fire



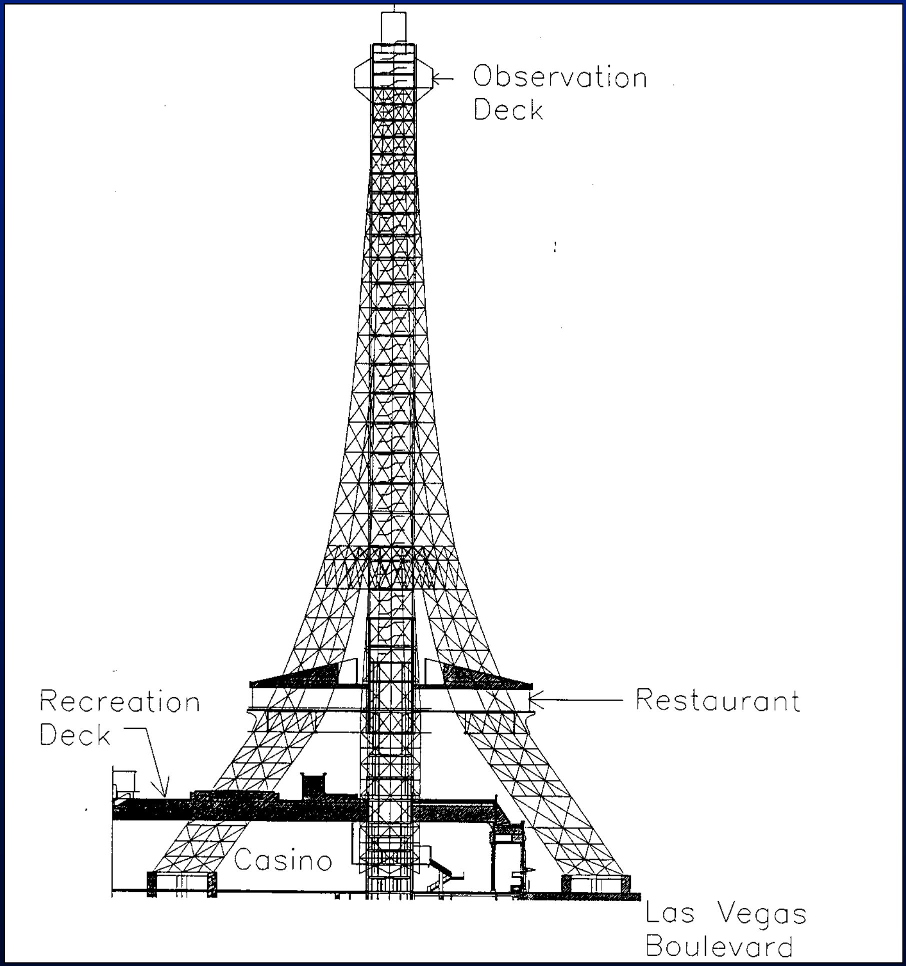
Column, Adjacent Base Plate and Floor Slab Discretized into Finite Element Mesh



Steel Temperature History for Maintenance Refuse Fire



Eiffel Tower II



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Calculated Steel Temperatures in Eiffel Tower II for Four Fire Scenarios